REMARKS

By the present Amendment, claim 1 is pending in the application.

Support For Claim Amendment

The 2% to 20% by vol % of an austenite phase in a ferrite phase is disclosed in the specification at page 9, line 29 to page 10, line 2.

Heating the steel sheet without forming an external oxide layer is disclosed in the specification at page 9, line 29 to page 10, line 2.

Heating the steel sheet without forming an external oxide layer is disclosed in the specification at page 4, lines 14 to 15, The specification at page 3, lines 4 to 7 discloses that in recent continuous molten zinc plating systems, annealing systems using radiant heating furnaces are becoming mainstream.

Heating at 650°C to 900°C in the dual phase region during recrystallization annealing for 30 sec. to 10 min. is disclosed in the specification at page 12, line 34 to page 13, line 1.

The reducing step and reducing atmosphere is disclosed in the specification at page 13, lines 2 to 13.

The formation of the internal oxides, particles sizes and particle densities is disclosed in the specification at page 11, lines 1 to 6, page 11, lines 21 to 25, page 12, lines 18 to 23 and the last five (5) lines of original claim 1.

The cooling step for the steel sheet with the recited temperatures and times is disclosed in the specification at page 13, lines 33 to 36.

The zinc plating treatment in a zinc bath containing 0.01 to 1 wt % Al is disclosed in the specification at page 13, line 36 to page 14, line 3. A zinc bath with a plating temperature of 460°C is disclosed in the specification at page 14, lines 24 to 25.

The cooling step for the zinc plated sheet with temperature and time is disclosed in the specification at page 14, lines 13 to 15.

§102/§103

Claims 1, 2, 4 and 5 were rejected under 35 U.S.C. §103(a) as being unpatentable over Japan No. 2001-323355 to Honda et al.

Claims 1 and 2 were rejected under 35 U.S.C. §102(b) as anticipated by or, in the alternative, 35 U.S.C. §103(a) as being unpatentable over U.S. Patent No. 6,398,884 to Kyono.

Claims 1, 2, 4 and 5 have been rejected under 35 U.S.C. §103(a) as being unpatentable over Japan No. 2000-290730 to Suzuki.

These rejections, as applied to the amended claims, are respectfully traversed.

The Present Invention

Characteristic features of the present invention are:

(1). Using a radiant tube heating system in a recrystallization annealing before a molten zinc plating step provided in a continuous molten zinc plating system for suppressing the formation of an external oxide layer or Fe oxides on the surface of the steel sheet.

(2). Controlling a reducing atmosphere where a ratio PH_2O/PH_2 of the steam partial pressure PH_2O and hydrogen partial pressure PH_2 of the reducing atmosphere is $1.4 \times 10^{-10} \times T^2 - 1.0 \times 10^{-7} \times T + 5.0 \times 10^{-4} \leq PH_2O/PH_2 \leq 6.4 \times 10^{-7} \times T^2 + 1.7 \times 10^{-4} \times T - 0.1$.

(3). Forming at least one type of internal oxide particles selected from Al oxide, Si oxide, Mn oxide, or complex oxide composed of at least two of Al, Si and Mn having an average diameter of the particles of 0.001 to 1 μm.

(4). Controlling the density of the oxide particles to not more than 1×10^{11} particles/cm^2 at a region from the surface of the steel sheet to a depth of 2.0 μm.

Japan No. 2001-323355 (the "'355 patent")

The technology disclosed in JP2001-323355 ('355 patent) relates to a high Si containing high strength steel sheet and coated steel sheet excellent in corrosion resistance and

platability, where a steel layer containing 0.4 - 2.0 mass % internal oxide of SiO_2 is formed as a first layer to less than 3 μm thickness on the surface of the steel sheet which containing Si: 0.4 - 2.0 mass %, and then a hot-dip galvanized layer having a composition containing 0.2 - 10 mass % Al and a balance Zn is formed on the above steel layer. This internal oxide layer of SiO_2 having a thickness of several thousand Å is formed by means of controlling a combustion air ratio performed in the oxidizing zone during recrystallization annealing before the hot-dip galvanizing step, then reducing such oxidized layer in a reducing zone for forming SiO_2 internal oxide. This is a key technology of the '355 patent. This technology is different from the present inventive feature of suppressing an external oxide layer. The attached Fig. A shows oxide formation on the steel sheet according to the inventor's experiment.

[Pink color portion represents SiO_2.

Blue color portion represents Mn-O.

White color portion represent Mn-Si-O complex oxides.]

This means that the oxide formed on the steel sheet of the '355 patent clearly exists in layers at the interface between the steel sheet and the plated layer, and the internal oxide is grown by supplying oxygen during reduction of Fe oxide existing on the surface of the steel sheet. Therefore, the internal oxide formed in the '355 patent does not have an average diameter of 0.001 to 0.1μm and is a different kind of oxide compared with that of the present invention. This difference is caused by a difference in the production process.

Therefore, the '355 patent does not disclose or suggest the present inventive features as defined in amended claim 1.

__U.S. Patent No. 6,398,884 (the " '884 patent")__

The technology disclosed in USP 6,398,884 ('884 patent) relates to a hot-dip steel plate and alloyed hot-dip steel plate having an internal oxide layer on the surface, which is produced

by a process comprising the steps of: hot rolling, and heat treating at 650 - 950°C in an atmosphere not causing reduction while being adhered with a black skin scale, removing the black scale by pickling, recrystallization annealing, then hot dipping treatment.

This technical idea of the '884 patent is quite opposite to the present inventive idea of suppressing an external oxide layer. Further, the atmosphere which does not substantially cause a reduction described in the '884 patent is a 100% N_2 atmosphere (most preferable atmosphere), or N_2 containing O_2 less than 1% (preferable atmosphere). This means that the '884 patent does not disclose or suggest a control of PH_2O/PH_2 ratio in the atmosphere supplying the steam of the present invention.

Further, the '884 patent performs pickling after the formation of the internal oxide layer, which is quite different from the formation of the internal oxide layer and subsequently performing molten zinc plating according to the present invention. The '884 patent does not disclose or suggest the above mentioned features (1) to (4) of the present invention. Therefore, the technology disclosed or suggested in the '884 patent is quite different from the present invention as defined in amended claim 1 in the points of the plated steel sheet itself and the production process.

Japan No. 2000-290730 (the " '730 patent")

The technology disclosed in JP 2000-290730 ('730 patent) relates to a high strength hot-dip galvanized steel sheet containing the specified amounts of the compositions, and is produced by the steps of a process comprising: heating the hot-rolled steel sheet at 800-1000°C in an atmosphere containing hydrogen of 1 - 100 vol % and the ratio of the respective partial pressure between H2O and H2 in the specified expression according to the Si content, then cooling to 300°C with a cooling rate of more than 40°C/sec., then pickling under the condition of 0.05 - 5 g/m^2 pickling loss expressed in terms of Fe, then the steel sheet is again heated at 725 - 840°C for 5 to 200 sec., thereafter cooling it to below 600°C with a cooling rate of 2 - 50°C/sec., then performing continuous hot-dip galvanizing.

In the '730 patent, although Fig. 4 shows existing an internal oxide after continuous annealing (CAL), the '730 patent clearly discloses 1) forming the internal oxide in the CAL line, 2) pickling and removing the oxide in an amount of 0.05 - 5g/m^2 on the surface of the steel sheet, 3) annealing again in the reducing atmosphere to sufficiently reduce the oxide in CGL line (continuous galvanizing line).

Therefore, the feature of pickling after the formation of the internal oxide in the '730 patent is quite a different feature with respect to the formation of the internal oxide layer than suppressing the formation of the external oxide layer or Fe oxide according to the present invention. Further, there is an additional difference because performing annealing in a sufficient reducing atmosphere for the oxide in the hot-dip galvanizing line is quite a different process from the process defined in the present invention.

The difference of the surface condition is explained based on the following experiment of the inventors. According to the '730 patent, the internal oxide layer remains just before the hot-dip galvanizing treatment, and this oxide layer prevents a dispersion to the dissolved Si and Mn surface layer existing in the core portion of the base steel sheet during CGL annealing. This confirms the internal oxide layer is grown as shown in the attached Fig. B. Therefore, the internal oxide formed by the '730 patent is different from the oxide having an average diameter of 0.001 to 0.1 μm according to the present invention. The difference is caused by a difference in the process conditions.

The '730 patent does not disclose or suggest the above mentioned features (1) to (4) of the present invention. Therefore, the technology disclosed or suggested in the '730 patent is quite different from the present invention as defined in amended claim 1 in the points of the plated steel sheet itself and the production process.

Experiment 1

< Procedure >

A specimen (steel sheet) containing 1.5% Si - 1.6 % Mn was annealed at 780°C in an oxidation atmosphere with a combustion air ratio of 0.9, and reducing annealing was performed under the atmosphere of H_2: 5%, N2: 95%, H_2O/H_2 ratio of 2×10^{-3} in the reducing zone. Then hot-dip galvanizing was performed.

<Result>

It was confirmed that the Si, Mn internal layer was formed in layers as shown in the attached Fig. A.

<Comment>

It is assumed that there is a low oxygen concentration area inside of the iron oxide layer when the iron oxide layer is reduced. In this low oxygen concentration area, Si and Mn are already oxidized , and thus the formed oxides are grown and formed on the internal oxide layer in layers.

Experiment 2

<Procedure>

An experiment based on similar conditions as mentioned in the '730 patent was carried out and then the cross-sectional area of the plated steel sheet was observed.

(a). The steel sheet contained Si: 1.2%, Mn: 1.6%.

(b). Annealing was carried out at a temperature of 800°C for 60 sec. in an atmosphere of H_2: 5%, N_2: 95% and H_2O/H_2 ratio of 0.1. (This condition was the same condition as shown in Fig. 2 in the '730 patent.).

(c). No pickling.

(d). Annealing was further carried out at a temperature of 800°C for 60 sec. in an atmosphere of H_2: 5%, N_2: 95% and H_2O/H_2 ratio of 2×10^{-3}, then the annealed steel sheet was

cooled to 470°C, subjected to Zn plating in the Zn containing bath, then alloying treatment was carried out at a temperature of 450°C for 60 sec. (This condition is the same condition as shown in Fig. 3 of the '730 patent and the same condition mentioned in the '730 patent.).

<Result>

Polishing the cross-sectional area of the plated steel sheet, including the plated layer, and observing the Si distribution by EPMA was carried out. According to the conditions mentioned in the '730 patent, the internal oxide layer was formed in the steel sheet and there was no oxide particles in the plated layer, as shown in the attached Fig. B. Further, the internal layer having a thickness of several microns was formed as a film-like state. It was confirmed that oxides were not taken into the plated layer because the Zn dispersion was stopped at the internal layer during alloying treatment step.

<Comment>

(1). When the annealing atmosphere is adopted to the Formula (1) in the CAL annealing defined in the '730 patent, the dense internal oxide layer having several microns thickness is formed on the steel surface. On the other hand, when the annealing atmosphere is adopted outside the range of the Formula (1), the internal oxide layer does not form densely. (See: [0007] of the '730 patent).

This internal oxide layer of the '730 patent remains just before the zinc plating step, and this internal oxide layer prevents dispersion of the dissolved Si and Mn, which existed in the core portion, to the surface layer during CGL annealing. (See: [0028] of the '730 patent).

(2). The surface concentrate, which is an easily oxidized element of condensed Si and Mn formed at annealing is removed in the '730 patent. (See: [0042] of the '730 patent).

(3). Atmosphere in the CGL annealing of the '730 patent.

It is desirable in the '730 patent that the atmosphere is a fully reducing atmosphere for securing platability by means of reducing the oxide layer formed on the steel surface after pickling. (See: [0042] of the '730 patent).

The internal layer formed in (1) above absorbs the dispersed Si and Mn from the inside of the steel sheet, and then the internal oxide layer is formed, when the dissolved Si and Mn, which existed in the core portion, move from the internal oxide layer to the surface layer during CGL annealing. This is called as "Ostwald growth". Even if oxide particles having a diameter of more than 0.01 μm and less than 1 μm (defined in the present invention) are formed in the '730 patent, the thus formed oxide particles are energetically unstable and disappear during the internal oxide layer in Ostwald growth under the condition of the formation of the internal oxide layer having several microns in thickness.

(4). Dissolved Si and dissolved Mn remaining at the surface of the plated layer are removed by pickling in the '730 patent.

(5). In the '730 patent, there is no chance to form new oxide particles because the CGL annealing atmosphere is in a fully reducing atmosphere.

As mentioned above, the internal layer formed in above (1) absorbs the dispersed Si and Mn from the inside of the steel sheet, and then the internal oxide layer is formed, when the dissolved Si and Mn, which existed in the core portion, move from the internal oxide layer to the surface layer during CGL annealing by "Ostwald growth". Further, the thus formed oxide particles are energetically unstable, and disappear during the internal oxide layer in Ostwald growth under the condition of the formation of the internal oxide layer having several microns in thickness.

Summary

It is therefore submitted that amended claim 1 is patentable over Japan No. 2001-323355 and/or Japan No. 2000-290730 and/or U.S. Patent No. 6,398,884 standing alone or in combination.

CONCLUSION

It is submitted that in view of the present amendment and foregoing remarks, the application is now in condition for allowance. It is therefore respectfully requested that the application, as amended, be allowed and passed for issue.

Respectfully submitted,

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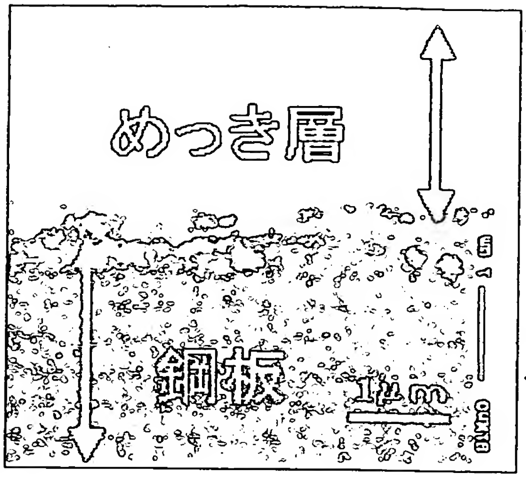
Fig. 2A



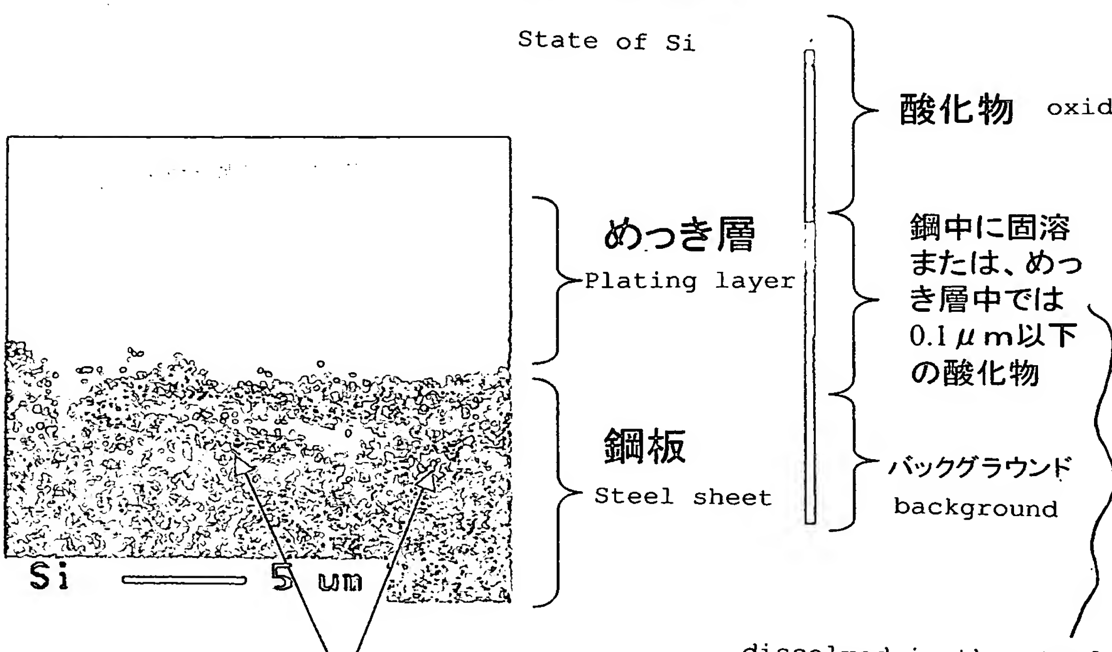
白:Mn-Si-O複合酸化物
空色:Mn-O
ピンク:SiO2

White: Mn-Si-O complex oxides
Blue: Mn-O
Pink: SiO_2

Fig. 2B

Siの状態

State of Si



酸化Si

Si oxide

dissolved in the steel sheet or oxide having a dimeter of less than 0.1 μm in the plated layer